DASA-1687

BURN MORTALITY STUDY OF 1831 PATIENTS

Max S. Rittenbury
Rhoda W. Maddox
Fred H. Schmidt
William T. Ham, Jr.
Boyd W. Haynes

22 November 1965

Prepared by

Medical College of Virginia
1200 E. Broad Street
Richmond, Virginia

Contract Number DA-49-146-XZ-423

Defense Atomic Support Agency
Washington, D.C. 20301

DASA-1687

BURN MORTALITY STUDY OF 1831 PATIENTS

Max S. Rittenbury
Rhoda W. Maddox
Fred H. Schmidt
William T. Ham, Jr.
Boyd W. Haynes

22 November 1965

Prepared by

Medical College of Virginia
1200 E. Broad Street
Richmond, Virginia

Contract Number DA-49-146-XZ-423

Defense Atomic Support Agency
Washington, D.C. 20301

BURN MORTALITY STUDY OF 1831 PATIENTS

by

Max S. Rittenbury, M.D., Rhoda W. Maddox, B.S., Fred H. Schmidt, M.S.*
William T. Ham, Jr., Ph.D. and Boyd W. Haynes, Jr., M.D.

The case records of 1831 patients who were consecutively treated on the Burn Unit at the Medical College of Virginia from 1949 through 1962 are presently undergoing an extensive statistical review. The purpose of this report is to present the results of a probit analysis of these records relating the age of the patient and the extent of the body surface area that was burned to the mortality rate. Weidenfeld (11) showed over 60 years ago that the prognosis for the survival of burn patients could be related to both the extent of the burn and the age of the patients, but it remained for Bull and Squire (2), and later Bull and Fisher (3), to define this relationship more fully by using the probit transformation of their mortality data to convert it into linear form and to improve the goodness of fit. This same method has since been used to report their mortality data by other authors (1,7), the most recent report being that by Pruitt et al of a study of a large series of patients (1100) treated at the Army Surgical Research Unit, Brooke Army Hospital (9).

From the Departments of Surgery and Biophysics, and the Strauss Surgical Research Laboratories, Medical College of Virginia, 1200 East Broad Street, Richmond 19, Virginia.

*Present address - Department of Biometry, Emory University, School of Medicine, Atlanta, Georgia.

Funds from these studies were made available from the Department of Surgery Research and Development Funds; the National Institutes of Health, Research Grant FR00016-02 supporting the Clinical Computer Center at this institution; and the Defense Atomic Support Agency Contract #DA-49-146-XZ-423.

Material and Methods

The Burn Unit of the Medical College of Virginia is responsible for the care of all patients admitted to this institution with thermal injuries. Most of the patients are from Richmond or are referred from the surrounding urban areas. One thousand and forty-nine of the patients whose records are being reviewed were admitted within less than five hours after they had sustained their injury, and only 7% of the patients were referred from another hospital where some form of primary treatment had been given.

Until 1956 most of the patients were treated using a "closed" method of wound care, but since 1958 most of the burn wounds have been treated by using an "open" method. At the present time the patients are taken to the Burn Unit dressing room immediately after they are brought to the hospital. Here the extent of the injury is determined and expressed as the percentage of the body surface area involved by both second and third degree burns, and immediate resuscitative therapy is started. This includes administering intravenous fluids (modified Evan's formula), tetanus toxoid or anti-serum, and prophylactic antibiotics, and cleaning and debriding the burn wound. These resuscitative principles have been unchanged during the time covered by this study. Systemic infections continue to be treated with the "appropriate" antibiotic as determined by in vitro bacterial culture and sensitivity tests. Every effort is made to obtain a clean burn wound ready for grafting at the earliest possible moment. An increasing number of selected wounds are being treated by primary excision and grafting.

The record of each patient was abstracted at the time of their discharge (either from the hospital or the Out-patient Clinic), and the information was placed on an IBM Source Document designed by Dr. E. I. Evans' co-workers following his death. This information was then placed on IBM tabulation cards, and the necessary computations were performed by the Clinical Computer Center. All of the patients dying with a thermal injury have been included, although a certain number of them probably died due to associated injuries.

The relationship between the extent of the body surface area that was burned, the age of the patient, the race and sex of the patient, and the patient's time of entry into the hospital to the mortality rate has been determined using both standard statistical methods and the probit analysis described by Finney. (4,5)

Results

Table 1 summarizes the total patient data. The patients are divided into groups according to the percent of the total body surface area involved by second and third degree burns and their age. These groups are comparable to those used by Bull and Fisher except for dividing their 0-14 year-old group into 0-4 years and 5-14 year-old groups, and their 15-44 year-old group into 15-39 and 40-44 year-old groups. The younger age group was subdivided because other authors have reported that the mortality was higher in the 0-4 year-old patients than in the 5-14 year-old patients. The 15-44 year-old patients were subdivided as shown because a preliminary study of the effect of age (10) that was made using another analytical technique had shown a change in the effect of age on mortality at the age of 40 years. The number of patients dying and the percent mortality is shown for each group.

Three hundred and sixty-nine of the patients died, giving an overall mortality rate of 20.15%. The mortality rate increased both with the patient's age and the percentage of the total body surface area that was burned. No patients survived with a burn involving more than 85% of the total body surface area, and only 9 patients survived with a total body surface area burn of 55% or greater. The 15 to 39 year-old patients were the most tolerant of the severe burns. The mortality rate was very low for patients less than 45 years of age with 25% or less of their body surface area burned, but it became appreciable in older patients with the same amount of burn. As reported by Moyer (8), these older patients tolerated a burn wound very poorly, and none of the patients 65 years of age or older lived with a burn greater than 25% of the total body surface area. Eighteen percent of this oldest group of patients with 0-4% body burns died.

The data was next subjected to the probit transformation noted earlier, and the overall results of this analysis are shown in Figure 1. In this figure the dashed line represents a rough plot of the mortality rate plotted against the percent of the total body surface area that was burned. The solid sigmoid curve shows the "smoothed," data and the straight line shows the probit transformation of the sigmoid curve. The probit values are given on the right ordinate. The percentage mortality and the probit scale are not linearly related because of the differences in their true values. Thus a probit value of 5.0 represents a mortality rate of 50%, but probit values of 3.0 and 7.0 respectively represent mortality rates of 2% and 98%. The use of this transformation makes it more convenient to fit the straight line to this raw data by the method of least squares in order to obtain an accurate equation to express its slope. This equation in turn can then be used both to verify the fit of other data and to predict the mortality for a given area of burn.

The mortality probit lines for the different age groups of patients are shown in Figure 2. The slope of each line represents the tolerance of that group of patients to the burn injury. It is obvious that the 15 to 39 year-old age group tolerate the burn somewhat better than any of the other groups, and the 65+ year-old age group show the least tolerance.

It is frequently very difficult or impossible to delineate areas of second degree burn from those with third degree injuries, and it is also very difficult to separate their different effects upon the patient. The role of infection in converting areas of deep second-degree injury into full-thickness injuries is also of importance (6), and, as yet, there is no data available on whether or not the "converted" full-thickness injury has a different effect upon mortality. Most patients have a combination of these two types of burns. Five hundred and twenty-four of the 1831 patients studied had no areas of third degree burn, and only 10, or 1.98% died. The causes of death in these patients with second degree burns were delerium tremens in one patient with a 2% surface area burn; a respiratory smoke burn in one 51 year-old patient who died less than 24 hours following admission; pneumonia and acute myocardial failure in an 86 year-old man who had a 4% surface burn and a body temperature of 79 degree F. on admission; aspiration from a feeding tube in a 3 year-old child with a 31% body burn, and bronchopneumonia and sepsis in 39 and 73 year-old males with 45% and 46% deep second degree burns respectively. The causes of death in the remaining 4 patients could not be determined.

As reported earlier (10) this low mortality rate associated with a partial thickness burn is striking, and therefore the mortality data for the patients with any amount of third degree burn has been determined and is presented in Table 2. The patient groupings are the same as those used in Table 1, but the degree of the surface area burn refers to the extent of the third degree burn and not to the total body surface area burn. The two groups of patients aged 5-14 and 40-44 with the smaller third degree burns were the only ones with no mortality. If this table is compared to Table 1 it is obvious that the mortality rate increased for each of the groups, and the total overall mortality rose to 27.5%. The mortality rates were very high when the area of third degree burn was greater than 25% for the 0-44 year-old age groups, greater than 15% for the 45-64 year-old age groups, and more than 5% for the 65+ year-old age group. Only one patient older than 40 years of age survived a third degree burn wound of greater than 24%.

The severity of this type of wound is again illustrated in Figure 3, showing the mortality probit lines for the major age groups. All of the lines are shifted to the left, and the lines for the 2 older age groups are steeper than those calculated on the basis of the total body surface area burn.

The equations for the mortality probit lines shown in Figures 2 and 3 and the calculated LA_{50} values* for both the amount of total

*The percentage of the total body surface area that produces a 50% mortality rate when involved by a thermal injury.

body surface area burn and the amount of third degree burn for the different age groups are given in Table 3. The LA_{50} values for the 0-4 year-old age group are lower than those for the 5-14 year-old age group, but the difference in these values is not statistically different at the P>.05 level. (5) The effect of the age is more apparent when the LA_{50} value for the patients in the 15-39 year-old age group is compared to that for the 40-44 year-old age group. The LA_{50} value for the total body surface area burn is 46.2% (95% confidence limit range 41-53%) for the 15-39 year-old age group, but this falls to 38.3% for the 40-44 year-old age group. There were too few patients in the latter group to calculate meaningful statistical differences however. The difference in the LA_{50} values is even greater for the patients in this age group with third degree burns. As expected the LA_{50} values decrease for the older patients. The total body surface area burn LA_{50} value range (95% confidence limits) for the 40-64 year-old age group is 24-40%, and for the 45-64 year-old group 23-38%, again illustrating that the patients between the ages of 40-44 years tolerate the burn wound in a manner similar to that shown by the older patients. It is notable that the difference between the LA_{50} values for both types of burn wounds in the 65+ age group is less than for the younger age groups, suggesting that other factors assume a relatively more important role in this group of patients. Despite the facts that the LA_{50} values for the percent of the body surface area involved by third degree burns were lower, and that patients with second degree injuries had a very low mortality rate, the subsequent data that will be presented is based on the percentage figure of the total body surface area burn' because previous authors have calculated their data on the same basis.

Figure 4 shows the mortality probit lines for the 0-4 and 5-14 year-old age groups with their overlaping 95% confidence limit lines, again showing that the response of these two age groups to the burn injury is similar. Figure 5 shows the lines for the 15-39 and 50-44 age groups. This again illustrates the changing tolerance to the burn wound that occurs at the age of 40 years. As noted earlier another analytical method (discriminate function analysis) has also been used to determine the effect of age upon mortality, and the same effect was apparent (10).

Equal mortality contours have been constructed from the mortality rates, and they are shown in Figure 6. The age in years is shown on the abscissa and the percent of the total body surface area that was burned is on the ordinate. Thirty year-old patients with a 50% total body surface area burn would therefore be expected to have a mortality rate of approximately 65%, but the same burn in 10 year-old patients would have a mortality rate of approximately 75%. This effect was not shown for the younger age groups in the data presented by Bull and Fisher, but it was present in the data presented by Winterscheid and Mereadino (12) and also Pruitt et al. (9)

Figure 7 is the mortality grid constructed from the mortality curves shown in Figure 6. Finer divisions for both the age of the patient and the percent of the total body surface area that was burned are used. The numbers in this grid are approximations only, and some of the patients with a value of 0 would die while an occasional patient with a value of 1 would survive. This grid differs from that of Bull and Fisher because it shows a decreased survival in the younger age group although, as noted above, the difference is not statistically significant. It is otherwise remarkably similar to theirs.

Effect of Race and Sex

Seven hundred and ninety-seven (43.5%) of the patients were Caucasians, and 1042 (56.9%) of the patients were males. An effort was made to determine whether or not the race and/or sex of the patients had a significant effect upon the mortality rates. The results are summarized in Table 4, with the patients divided according to their race, sex, and age. If the total numbers of Caucasian patients are compared to the total number of Negro patients, there is a significant difference in their mortality rates ($p<.001$),** but there is no significant difference in the overall mortality rates according to the sex of the patients, disregarding race.

The data in Table 4 shows that the overall mortality rate for the male patients in any age group except for 0-4 year-old Caucasian females was less than that for the other patient classifications. In the 0-14 year-old age groups it is significantly lower than the mortality rate for the Negro females in the same age groups. The Caucasian females have the highest mo... ity rates when the other age groups are compared however.

The relationships between the effect of race and sex of the patiént on mortality are best shown by the probit lines for the overall mortality rates for these patients depicted in Figure 8 and the LA_{50} values for each of the age groups shown in Table 5. The numerical

**Test for significance of difference in proportions.

value for the 95% confidence limits for the Caucasian male LA_{50} value is 39 to 56%, widely overlaping the same values for the Caucasian female, the latter being 33 to 50%. This is also shown in Figure 8 where the superimposed confidence limits for the Caucasian male probit line encompass the probit line for the Caucasian female. The respective LA_{50} 95% confidence limits for the probit line for the Negro females are 30 to 43%, and for the Negro males 31 to 40%. Although there is some overlaping of these limits (and these are not shown in Figure 8) the mean LA_{50} values of these patients are statistically different from those of the Caucasian male patients (5). A statistical comparison of the values shown in Table 5 for the different age groups shows that the Negro female LA_{50} value is statistically significantly lower than that of the Caucasian male in the 0 to 14 year-old age groups. There is no significant difference in values for the other age groups (5).

There is insufficient data to determine why this racial difference exists, although the lower socio-economic status of the Negro patient in the population from which these patients were taken may well be sufficient in itself to explain this difference.

Mortality rates by Postburn Time of Admission

The effect of the time of admission to the hospital after the patient is burned upon the mortality rate is shown in Tables 6, 7 and 8. Table 6 shows the percent mortality for the different times of admission in relation to the percentage of the total body surface area that was burned. The mortality rates were low and very similar for the patients with a burn of 24% or less of the total body surface area. In addition there was very little difference in the mortality rates for the patients with larger burns, although 15 of the 17 patients with 25 to 64 percent total body surface area burns that were admitted from 6 to 23 hours after their injury died. The lowered mortality rate for the 491 patients admitted 24 hours or more after their injury is due to the fact that only 3% of these patients had the more severe burns wounds. This, in combination with the fact that only 2 of the 75 patients admitted with burns involving more than 65% of their body surface area were admitted after one day, either reflects the immediate referral of the more severely burned patients to the Burn Unit without a significant delay in surrounding hospitals or communities or the death of these patients prior to their admission.

Table 7 lists the LA_{50} values for the same patient groups that contain sufficient numbers of patients for analysis and that were listed in Table 6. The changes in the LA_{50} values relative to the age of the patient are similar to those noted earlier, but there is no significant difference relative to the time of admission to the hospital. The overall probit equations for the admitting times are shown in Table 8, and the LA_{50} values are very similar. This data shows that the transit time from the place of injury to the Burn Unit is short for the majority of these patients, that the more severe burns are probably sent directly to this unit, and that those patients with the larger burns who are not brought to the unit shortly after burning probably do not survive long enough to be brought there later, Change in Survival Time in Fatal Cases

An effort has been made to determine whether or not there has been an increase in the survival time of those patients dying of the burn wound within the period of time covered by this study. The patients were divided according to their mortality probability as determined from Figure 5, and by three nearly equal time periods covered by this study. Table 9 shows this division and the numbers of patients that survived for various times in each of these groups. One hundred and seven of the patients with a mortality probability of 0 to .4 died, and the proportion of the cases in each of the time periods studied that survived for 8 or more days is essentially the same. However the mean survival time in this group of patients did decrease from an average of 32.1 days during the first 4 years to 21.9 days during the last 5 years of this study. These patients would all have total body surface area burns of less than 42%, and therefore the change could probably be due to associated injuries, although the information to prove or disprove this assumption is not yet available.

There were 130 patients who died that had a high probability of dying (.5-.9), and the mean survival time for these patients was essentially unchanged during the time periods covered by this study. The proportion of patients that survived for 8 or more days was also remarkably uniform for each time period.

One hundred and eighteen of these patients had a mortality probability of 1.0, implying only a minute statistical chance for survival. In the years 1949 through 1952 55% of these patients died within the first 2 days following their injury, but this percentage fell to 25% for the latter two periods. The survival time gradually increased, and whereas only 14% and 25% of the patients seen from 1949 to 1952 and from 1953-1957 respectively survived for 8 or more days 40% of the patients seen in 1958-1962 survived for this time. The mean survival time increased from 3.9 days in the first time period to 9.7 days in the latter.

This data would show that, despite other evidence that the over-all mortality for the burn patient has not decreased, progress has been made in prolonging life in the patients with major burns.

Mortality Rate by Year of Admission

The mortality rate was also determined for the patients according to their year of admission, these being divided into the same time periods used in Table 9. The number of patients, the percent of the total body surface area burned, and the overall percentage mortality is shown in Table 10. The patients with 0 to 4% total body surface area burns had no mortality until 1953, and since that time only 14 of 348 patients, or a total of approximately 4%, have died. The mortality rates for the patients with 15 to 24% and 35 to 44% body surface area burns has doubled in the last 10 years covered by this study, and the mortality rates for all of the larger surface burns has increased. The overall mortality rate was only 17.2% for the first 4 years covered by this study, but this had risen to 23.3% for the last 5 years.

Table II lists the probit equations and the LA_{50} values by the different periods of admission. The LA_{50} value for the first 4 years of the study was 44.3%, but this decreased significantly to 33.2% for the last 5 years covered by the study (5). This is shown in Figure 9 wherein the probit lines and 95% confidence limits for these years are shown. The probit lines themselves lie almost completely outside of the confidence limit lines except for burns of less than 20% of the total body surface area. These data show that there has been a definite increase in the mortality rate and an apparent decrease in the tolerance of the patients treated in this institution to a given burn wound.

It is difficult to account for this change using these types of statistical analyses. A compilation of data presented in Table 10 reveals that essentially the same percentage (23.9%, 19.9%, and 24.2%) of the admissions during the three periods of time being studied were patients with greater than 25% total body surface area burned although the mortality rate rose for these selected patients from 61.7% to 73.2% during this time. If the same calculations are carried out relative to the numbers of patients admitted with 15% or more total body surface area burns the same percentage of admissions had burns of this magnitude in both the first 4 years of this study and the last 5 years, although the mortality rate again rose 10 percentage points. Therefore, the difference in mortality can not be due to any significant increase in the numbers of patients that were admitted to this Burn Unit with larger burns.

However the incidence of the patients in various age groups that were admitted in these different time periods did vary significantly. The incidence of patients aged 0 to 14 years decreased progressively from 1949-52 (46%) to 1958-62 (37%), while the incidence of patients aged 45-64 years increased from 11% to 20% ($p<.001$)**. The incidence of patients in the other age groups remained the same. This shift

**Test for significance of difference in proportions.

would therefore affect the overall probit lines and mortality rates calculated according to the year of admission. The differences in these values from the first 4 years to the last 5 years of this study are therefore probably due to a significant increase in the number of older patients and a decrease in the number of younger patients admitted during the latter period. This direct relationship is presently being analyzed using discriminate function analysis.

Discussion

The present study has been carried out using the same method of analysis as that of Bull and Fisher and Pruitt et al in order to facilitate comparing the mortality rates in large numbers of burn patients treated in 3 separate burn centers. Certain differences exist in the patient populations, however, and these could account for certain apparent differences in the mortality rates. The series reported by Bull and Fisher and the present one were composed of civilian patients treated at different times. They likewise do not present socio-economic data that could be important in view of the effect of race (or socio-economic status) shown in the present series. The patients comprising the series reported by Pruitt et al (Brooke Army Hospital) were highly selected in that they were either military personnel or dependents, and they were drawn from military bases scattered throughout the United States and in some instances foreign countries. In addition a significant number of the patients treated at Brooke Army Hospital are transferred (largely by air transport) from other military hospitals after resuscitative therapy has begun. Those patients that died before they were referred due either to the seriousness of their injury or a delay in transportation facilities have not been included in their series. These would be other selective processes not present in the series of Bull and Fisher or this one.

The data from these three series relative to the mortality rate for different patient age groups is presented in Table 12. The mortality rate for each group reported by Bull and Fisher is much lower than they reported by the Brooke Army Surgical Research Unit or the present series. This table, as noted, does not have strictly comparable age groupings for the Brooke series due to the method by which their data was presented, and their mortality rate for the older patients is therefore not strictly comparable.

The raw mortality rates are strongly influenced by the number of patients within any series with relatively minor or extremely severe burn injuries. Therefore, in order to compare these rates more meaningfully, the groups of patients with minor burns having little or no mortality have been excluded, and the results are shown in Table 13. It is obvious that a large number of the patients reported by Bull and Fisher were admitted to their hospital with minor burns, and only 515 patients, or 18.4% of their total series, had burns involving more than 14% of the body surface. Seventy-two percent of the Brooke series and 55% of this series of patients had the more severe burn injuries. The overall mortality rate for these more severely burned patients reported by Bull and Fisher increases to 29.3%, somewhat closer to those reported from Brooke Army Hospital and MCV. The percentage of patients aged 0 to 14 years and 15 to 44 or 49 years in each series are fairly evenly distributed, and without determining the extent of the total body surface area burn in each series, the MCV mortality rates appear to be significantly higher.

Table 14 compares the LA_{50} values for the total body surface area that was burned by age groups for the three series. Both Bull and Fisher and the Brooke Army Hospital series LA_{50} values for the age groups 0 to 14 years were statistically significantly higher than MCV's.

Pruitt et al, reporting on the patients treated at the Brooke Army Hospital, showed that the mortality rate for their 0 to 4 year old patients is higher than that for the 5 to 14 year old patients. Figure 10 shows the mortality probit lines for the total body surface area burn for this age group from the three series now being compared. It is obvious that for burns of more than 25 to 30% of the body surface area there is a difference in mortality. As noted earlier in Tables 4 and 5 the 95% confidence limits for the LA_{50} values of the patients treated at MCV in the 0 to 4 age group ranged from 31 to 44%, the latter being close to the values reported in the other series. The significantly decreased LA_{50} values for the Negro females in this age group, and the overall decreased tolerance to the burn wound shown by the Negro patients in this series could account for the difference in the LA_{50} value. Figure 11 reproduces the mortality probit lines for the percent for the total body surface area that was burned for the 0 to 14 year old age group, and here the lines representing the patients from Bull and Fisher and Brooke Army Hospital lie very close, with a significant decrease in the LA_{50} value being shown again, and for the same reason, for the MCV patients. Therefore the patients reported in this series do not show the significantly increased mortality reported by Pruitt et al for the 0 to 4 year old age group, although the total mortality for these younger patients was higher and the LA_{50} value was lower than with either of the other series.

In addition the Brooke Army Hospital 15 to 49 year old age group LA_{50} value was significantly higher than that for the 15 to 44 year old age group from both MCV and Bull and Fisher. The age group encompasses most of the active military personnel. The remaining LA_{50} values are essentially the same.

One of the major conclusions that can be made from these data is that the mortality rate for the burned patient has not significantly changed during the 10 years prior to 1962, although there is data showing, as have others, that the survival time for fatal cases is increasing significantly. The effect of primary excision of the burn wound and/or the use of newer local and systemic antibiotic and chemotherapeutic agents on mortality remains un-evaluated at the present time although the preliminary reports have been encouraging (6).

The probit type of analysis has certain definite limitations, and some of these have been illustrated in the present series. It is limited in the studies quoted by the use of only 2 factors to determine mortality, these being the age of the patient and the percent of total body surface area that was burned. It is obvious that the total body surface area burned is not as significant a factor as the area of third degree burn that is present, but the clinical difficulties in delineating the area of a second degree from those of third degree burns are well know and actually limit the use of this factor. In addition there are certain other factors that necessarily have an effect upon the patient's chance of living or dying. These would include the presence of pre-existing disease, the occurrence of associated injuries, and the occurrence of certain post-injury complications. This type of information is not available using the probit transformation of the raw mortality data, even by grouping the patients according to the different complications that occur. A preliminary study of the important factors in determining lethality in burn patients has previously been presented, (10) and the results have led the authors to believe that the use of a discriminate function type of analysis is more useful than the use of probit analysis. It is hoped that other authors will use this type of analysis to study their patients so that a better understanding of these various factors can be obtained.

Summary

The present study has presented the results of a probit analysis of the mortality rate seen in 1831 burn patients treated between the years 1949 and 1962 at the Medical College of Virginia Hospital. The difference in the mortality rate has been related both to the age of the patient and to the percentage of the total body surface area and the third degree surface area burn suffered by the patient. In addition an attempt has been made to show the effects of the race and sex of the patient, the time of admission to the hospital following the burn injury, and the year of admission on mortality.

The results of this study confirm the relationship existing between the expected mortality and the age and amount of the body surface area covered by the burn, but, as shown in Table 9, 107 patients or 29% of those dying had a less than 50% chance of dying according to this analysis. This is a large degree of error and the total error in predicting mortality by this method would be higher if those patients with a probability of dying of greater than 50% who actually lived were included. This shows a definite need for a more accurate means to predict burn mortality. There was no effect on mortality according to the time of

admission of these patients to the hospital following the burn. The race of the patient was found to be important, but the sex was not.

This data shows that progress has been made in prolonging the survival time of those patients that eventually die, but the overall true mortality rate has remained unchanged, both at this hospital and in comparison with other series.

The LA_{50} value has been found to be a very useful figure to express the tolerance of a patient or a selected group of patients has for the burn injury, and these values were significantly lower for the younger patients treated at the Medical College of Virginia when compared to those reported by Bull and Fisher and Pruitt et al. The best survival figures for the middle aged patient has been reported by Pruitt et al from the series at Brooke Army Hospital.

This data has shown a striking difference between the effects of second and third-degree burn injuries in that the partial-thickness injury is rarely lethal.

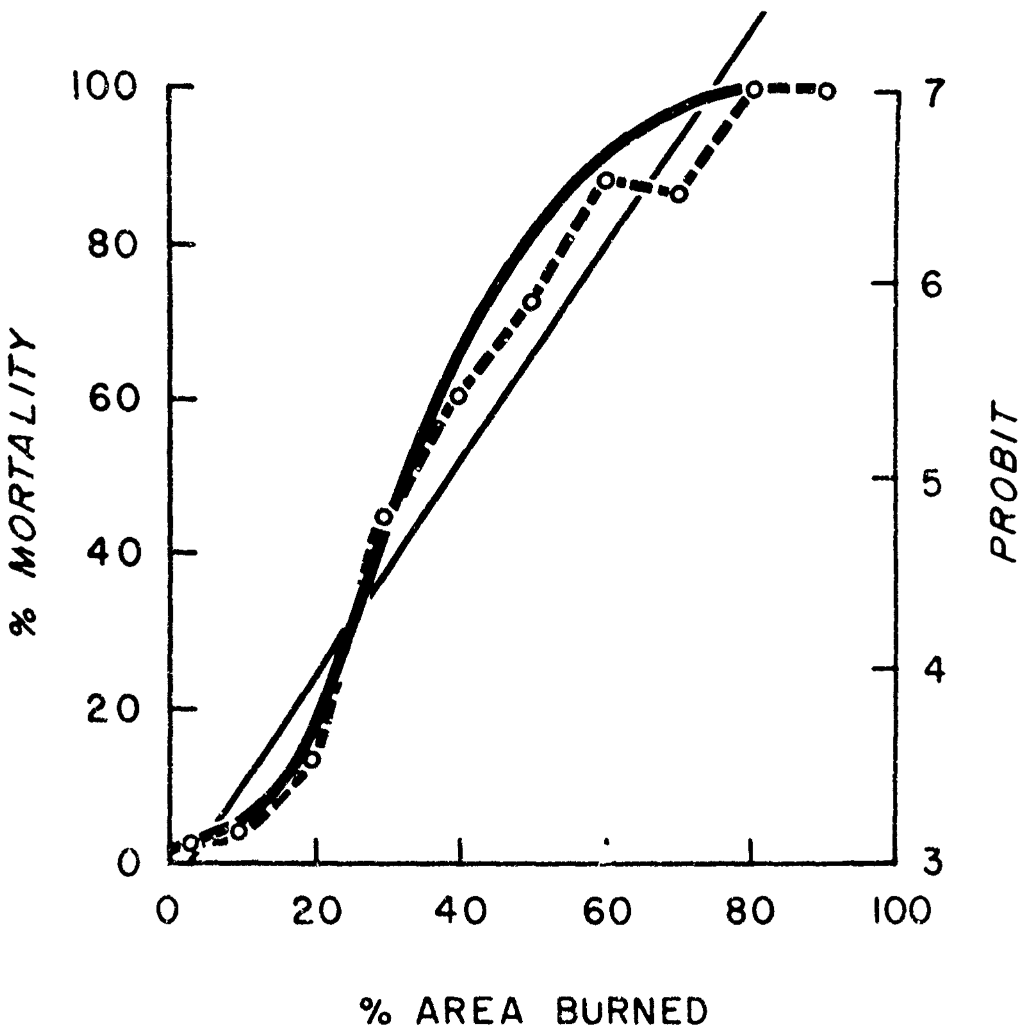

FIGURE 1

Probit transformation of MCV mortality data. See text for explanation.

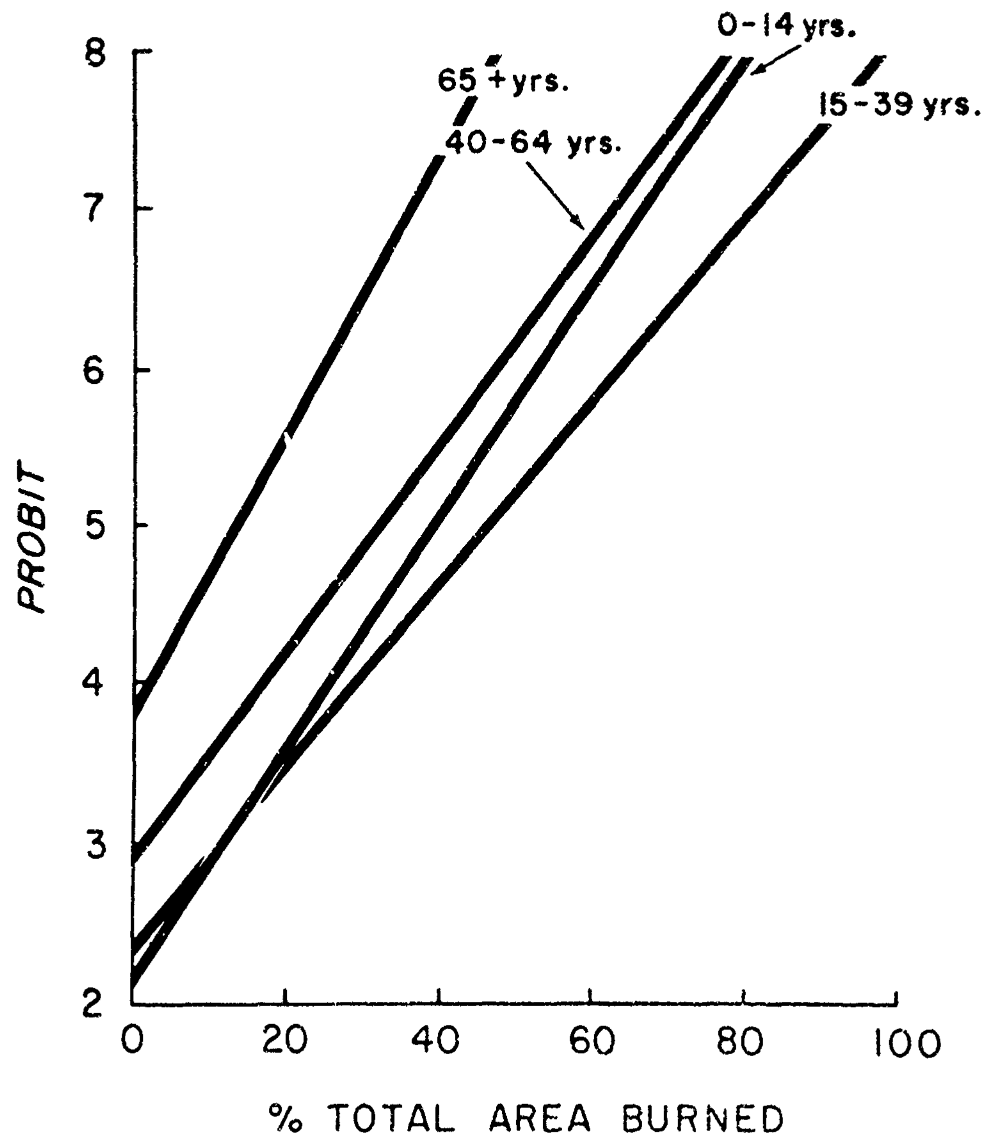

FIGURE 2

Mortality probit lines for different age groups related to the total body surface area burned.

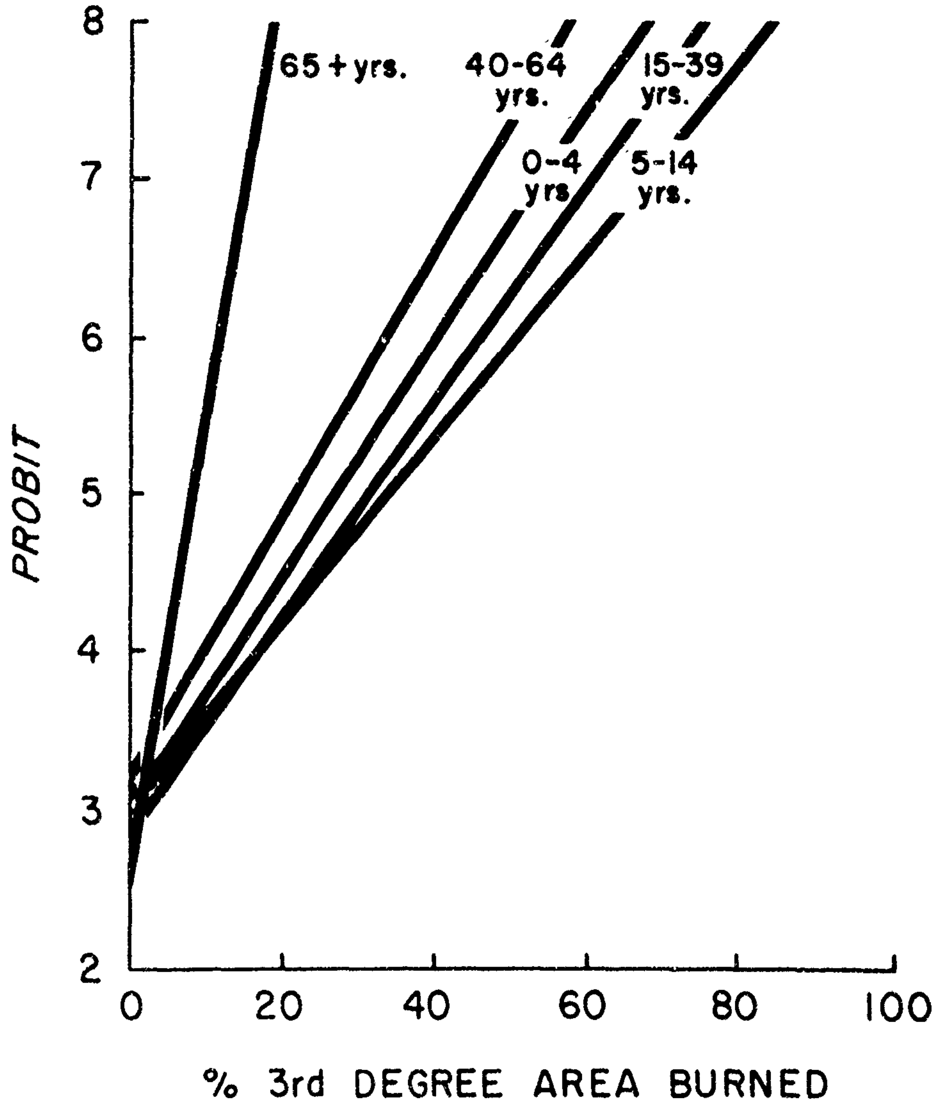

FIGURE 3

Probit transformation of data for percent of body surface area involved by thrid degree wound.

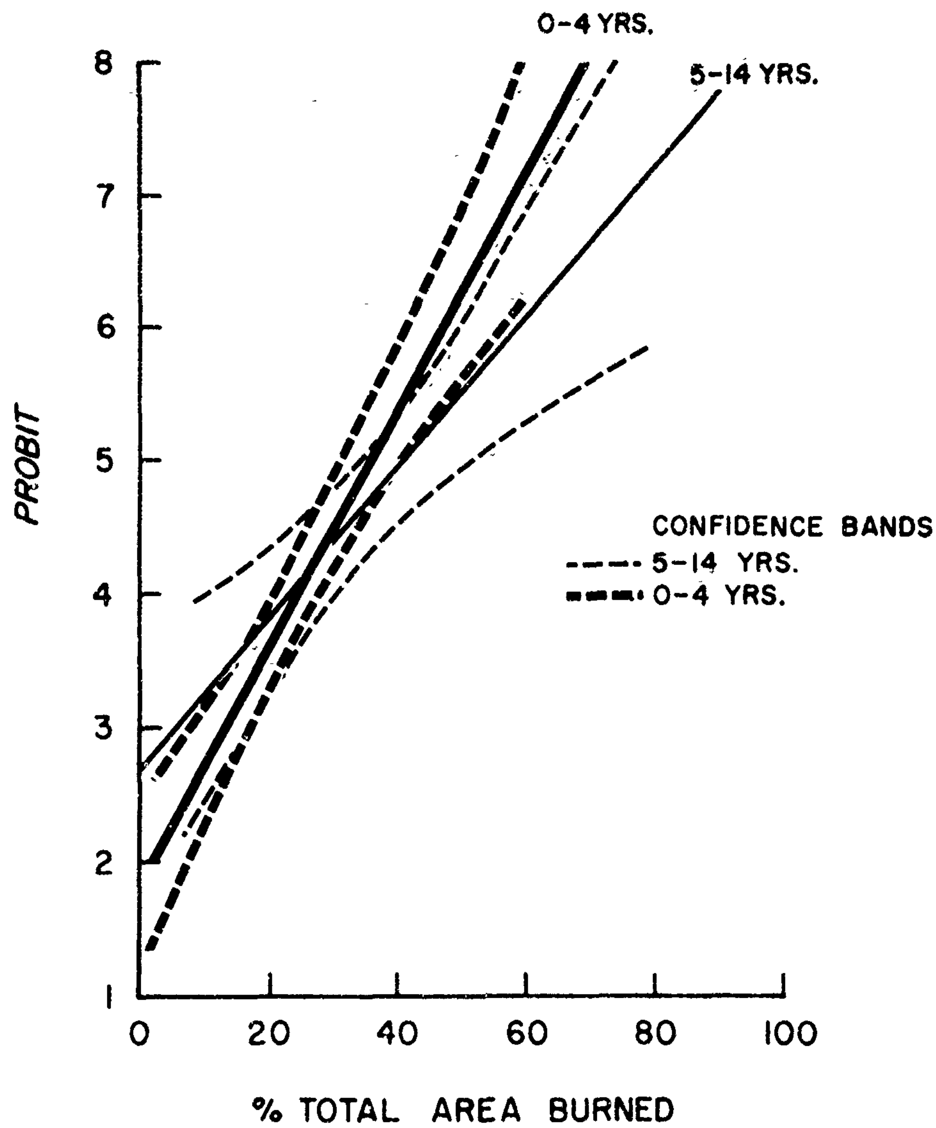

FIGURE 4

Mortality probit lines for 0-4 and 5-14 year old age groups with 95% confidence lines.

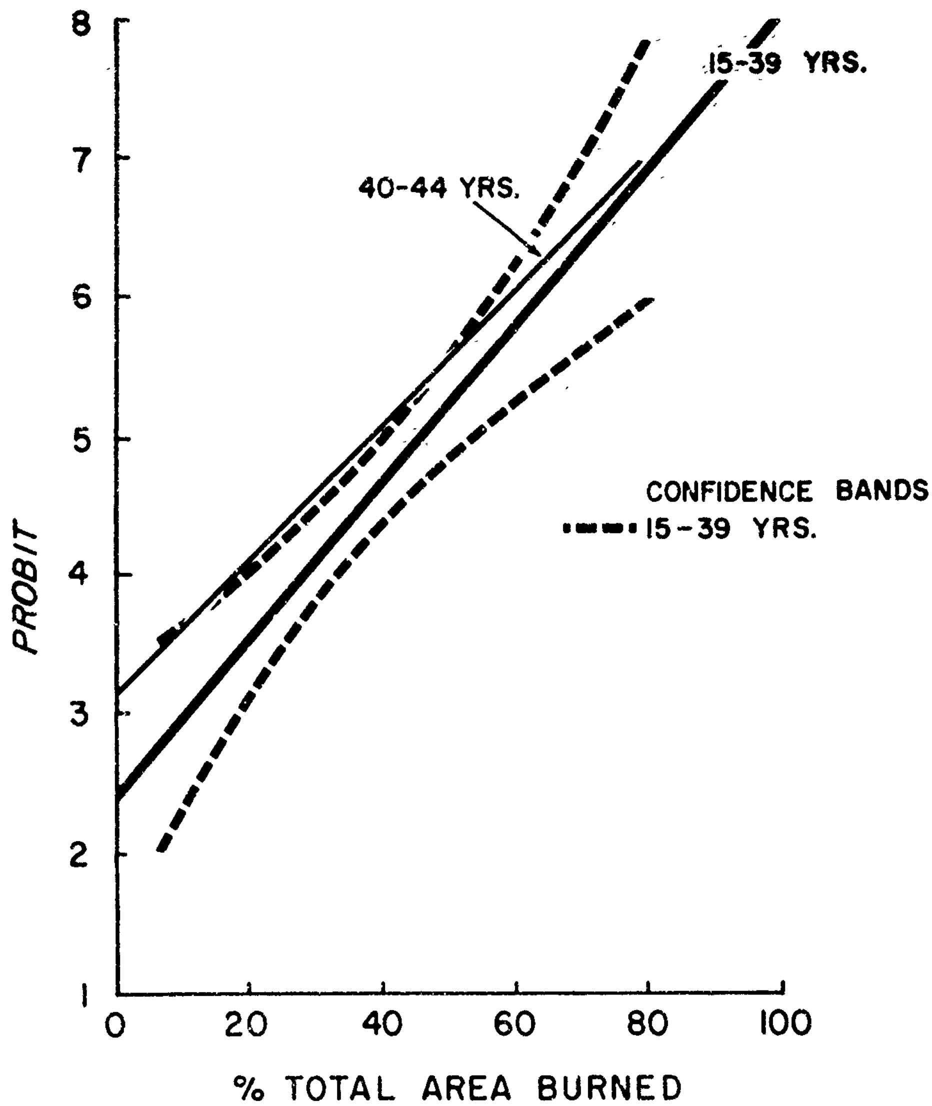

FIGURE 5

Mortality probit line with 95% confidence limits for 15-39 year old age group, and probit lines for 40-44 year old age group.

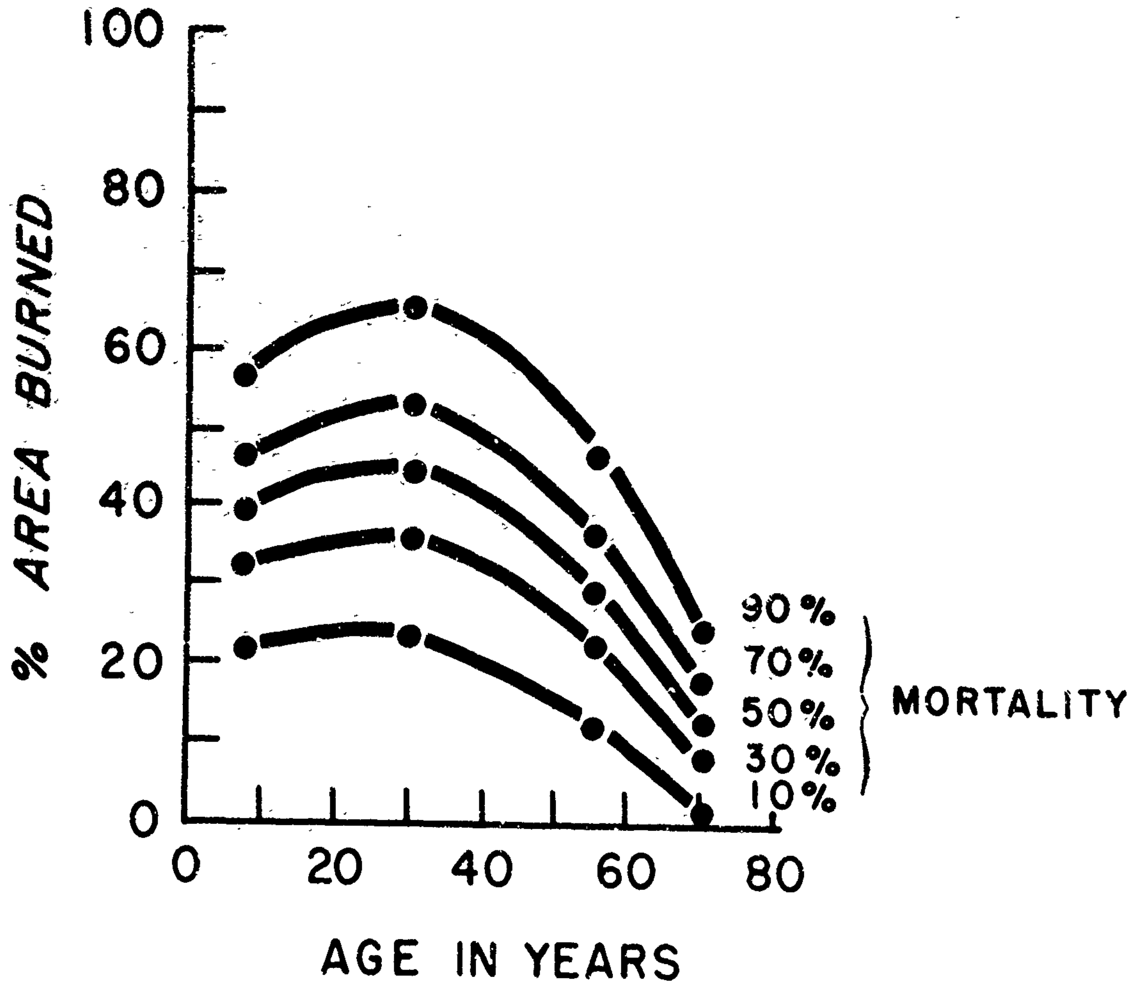

FIGURE 6

Mortality contours showing the mortality rates for the different ages and percentage of total body surface burns.

GRID OF APPROXIMATE MORTALITY PROBABILITIES														
% Body Area Burned	Age - Yrs.													
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
68 or more	1	1	1	1	1	1	1	1	1	1	1	1	1	1
63 - 67	1	1	1	.9	.9	.9	.9	1	1	1	1	1	1	1
58 - 62	1	1	.9	.8	.8	.8	.8	.9	1	1	1	1	1	1
53 - 57	.9	.9	.8	.8	.7	.7	.7	.8	.8	.9	1	1	1	1
48 - 52	.8	.8	.7	.7	.6	.6	.6	.7	.8	.8	.9	1	1	1
43 - 47	.7	.7	.6	.5	.5	.5	.5	.6	.7	.7	.8	.9	1	1
38 - 42	.6	.5	.5	.4	.4	.4	.4	.5	.5	.6	.7	.8	.9	1
33 - 37	.5	.4	.3	.3	.3	.3	.3	.4	.4	.5	.6	.7	.9	1
28 - 32	.4	.3	.2	.2	.2	.2	.2	.3	.3	.4	.5	.6	.7	.9
23 - 27	.2	.2	.1	.1	.1	.1	.1	.2	.2	.3	.3	.5	.6	.8
18 - 22	.1	.1	0	0	0	0	.1	.1	.1	.2	.2	.3	.5	.7
13 - 17	0	0	0	0	0	0	0	0	0	.1	.1	.2	.3	.5
8 - 12	0	0	0	0	0	0	0	0	0	0	0	.1	.2	.3
3 - 7	0	0	0	0	0	0	0	0	0	0	0	0	.1	.2
0 - 2	0	0	0	0	0	0	0	0	0	0	0	0	0	.1

FIGURE 7

Mortality grid according to age and percent of total body surface area burned.

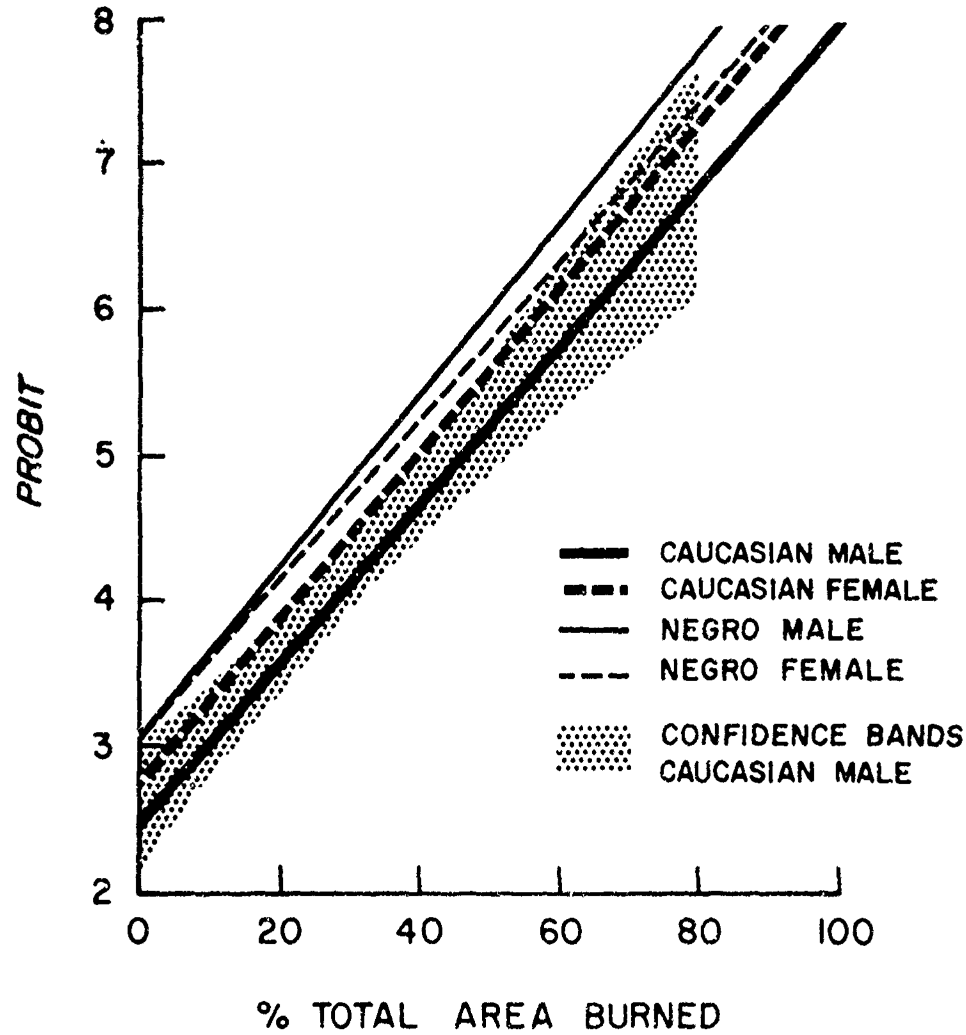

FIGURE 8

Mortality probit lines according to race, sex, and percent of total body surface area burn.

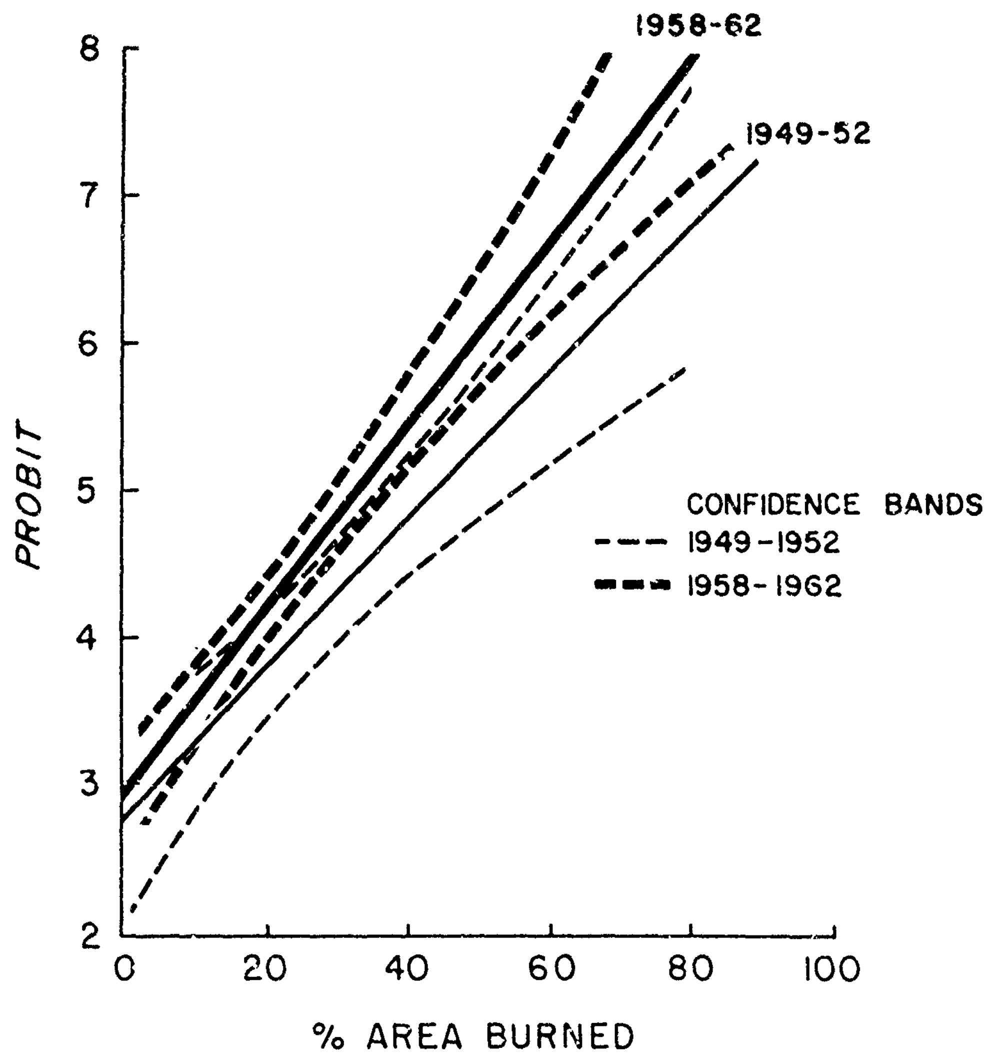

FIGURE 9

Mortality probit lines and 95% confidence limits 1949-52 and 1958-62, for the percent of total body surface area burn.

	NO. of PTS.	% MORTAL.	LA 50
B & F	1041	UNKOWN	49.4%
BROOKE	171	17.5	45.1%
MCV	493	11.1	35.5%

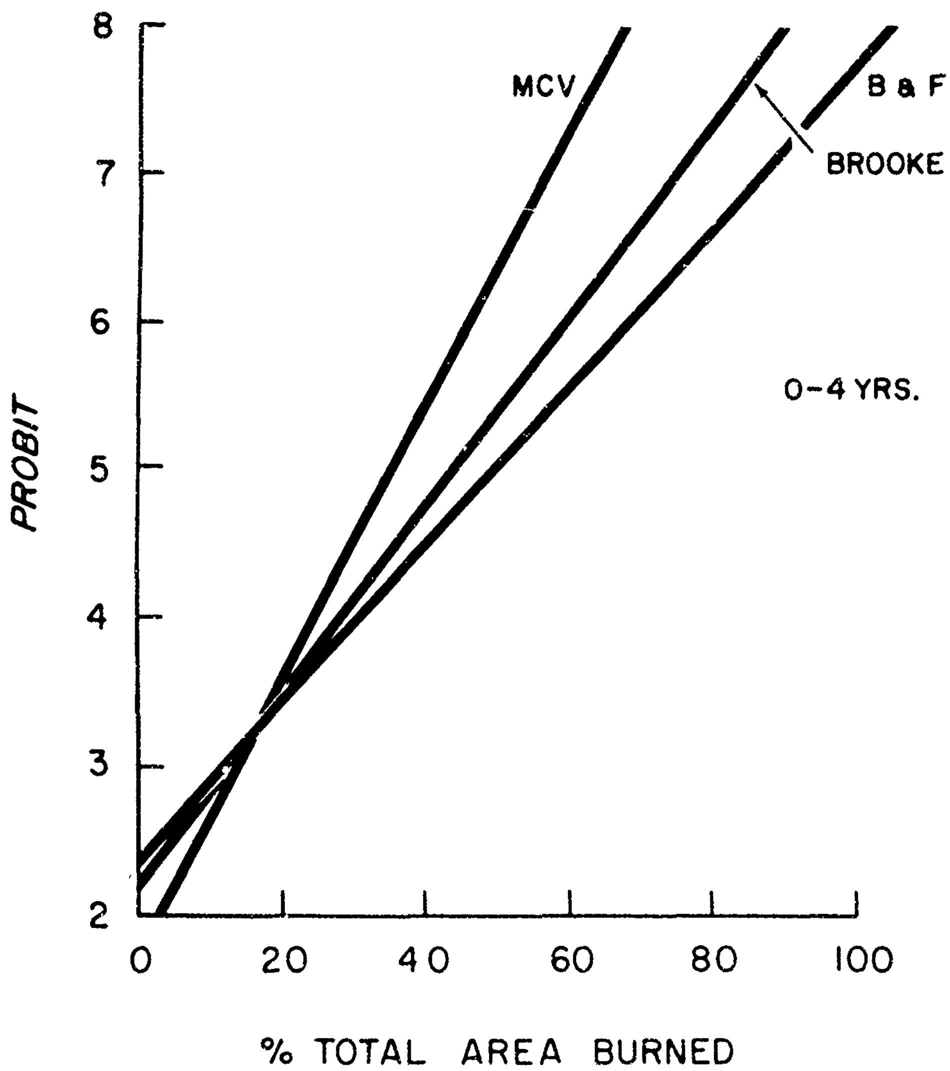

FIGURE 10

Mortality probit lines for age group 0-4 years for present series and those reported by Bull and Fisher and Brooke Army Hospital.

	NO.of PTS.	% MORTAL.	LA 50
B a F	1366	3.4	49.7 %
BROOKE	238	18.1	48.5 %
MCV	769	13.5	39.2 %

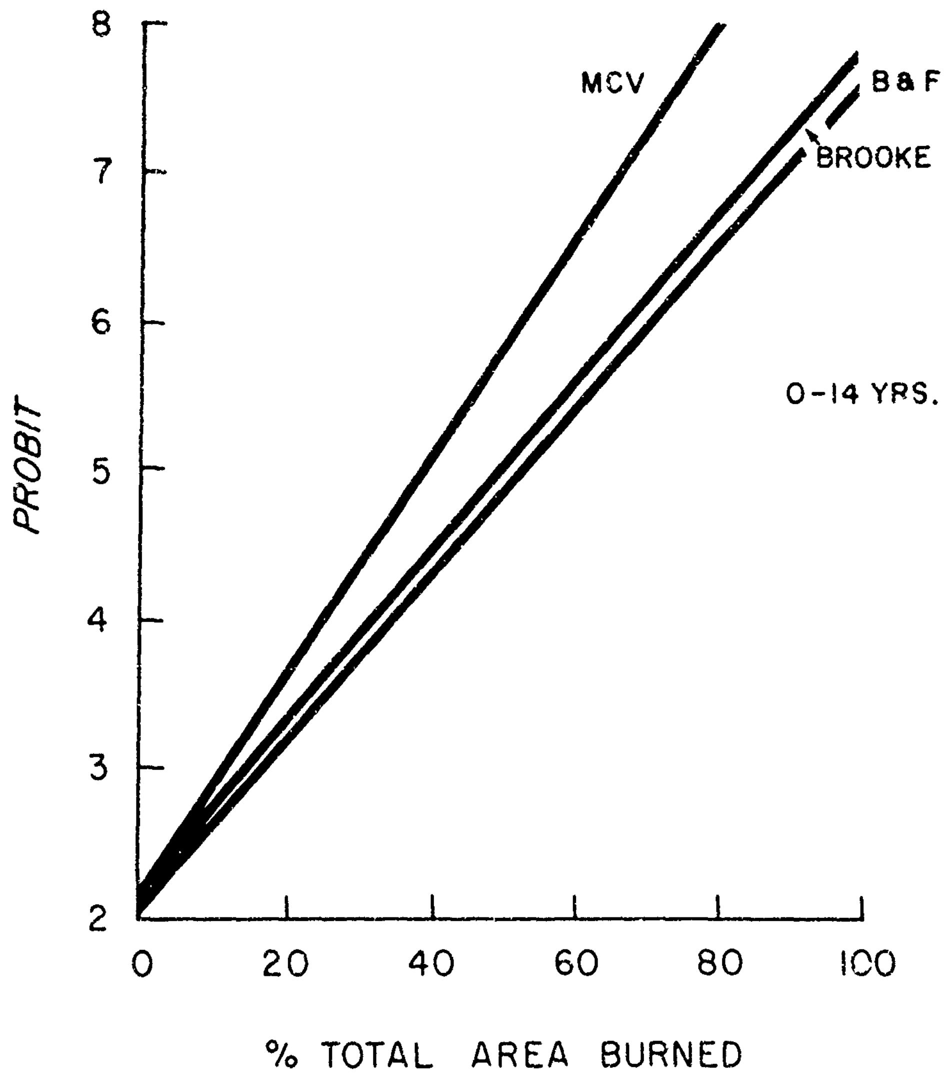

FIGURE 11

Mortality probit lines for age group 0-14 years for present series and those reported by Bull and Fisher and Brooke Army Hospital.

TABLE 1
MCV CLINICAL BURN DATA 1949-1962

% TOTAL	0-4 YRS.			5-14 YRS.			15-39 YRS.			40-44 YRS.			45-64 YRS.			65 + YRS.		
Area Burned	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	Mort.
0-4	107	0	0	59	0	0	121	0	0	27	2	7.4	74	2	2.7	62	11	17.7
5-14	232	3	1.3	86	0	0	167	0	0	27	1	3.7	112	[illegible]	5.3	57	23	40.3
15-24	79	3	3.8	56	4	7.1	86	3	3.5	5	0	0	39	12	30.8	21	15	71.4
25-34	31	12	36.7	24	10	41.7	37	10	27.0	11	3	27.3	[illegible]	11	[illegible]	15	15	100.
35-44	16	11	68.7	23	12	52.2	24	11	45.8	4	4	100.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.
45-54	9	7	77.8	7	5	71.4	18	9	50.	2	2	100.	13	13	100.	[illegible]	[illegible]	100.
55-64	11	11	100.	9	7	77.8	15	12	80.0	2	2	100.	5	4	80.	[illegible]	[illegible]	100.
65-74	2	2	100.	5	4	80.0	12	10	83.3	3	3	100.	5	5	100.	2	2	100.
75-84	1	1	100.	3	3	100.	9	9	100.	4	4	100.	1	1	100.	2	2	100.
85-94	3	3	100.	2	2	100.	13	13	100.	0	0	0	4	4	100.	2	2	100.
95 +	2	2	100.	2	2	100.	3	3	100.	0	0	0	1	1	100.	4	4	100.
Totals	493	55	11.1	276	49	17.7	505	80	15.8	85	21	24.7	282	65	23.0	190	[illegible]	52.1

Total No. of Pts: 1831
Total No. of Deaths: 369
Mortality: 20.15%

TABLE 2
MCV CLINICAL BURN DATA - 3rd DEGREE 1949-1962

%3rd DEG.	0-4 YRS.			5-14 YRS.			15-39 YRS.			40-44 YRS.			45-64 YRS.			65 + YRS.		
Area Burned	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	% Mort	No. of Pts.	No. of Deaths	% Mort.	No. of Pts.	No. of Deaths	Mort.	No. of Pts.	No. of Deaths	% Mort.
1-4	159	5	3.1	86	0	0	154	1	0.6	[illegible]	0	0	[illegible]	4	4.2	[illegible]	12	[illegible]
5-14	69	5	7.2	50	3	6.0	76	5	[illegible]	[illegible]	2	5.4	[illegible]	12	[illegible]	[illegible]	[illegible]	[illegible]
15-24	21	6	28.6	29	7	24.1	33	8	24.2	5	2	40.0	24	[illegible]	[illegible]	[illegible]	[illegible]	100.
25-34	18	12	66.7	21	12	57.1	24	16	[illegible]	3	3	100	11	11	100.	[illegible]	12	100.
35-44	6	5	83.3	13	9	69.2	9	7	77.8	3	3	100	5	5	100.	[illegible]	[illegible]	100.
45-54	11	10	90.9	8	6	75.0	12	8	66.7	3	3	100.	11	[illegible]	[illegible]	[illegible]	[illegible]	100
55-64	3	3	100.	4	3	75.0	14	14	100.	1	1	100.	[illegible]	[illegible]	100	[illegible]	[illegible]	100.
65-74	2	2	100	4	4	100.	8	8	100.	1	1	100.	[illegible]	[illegible]	100	[illegible]	[illegible]	100.
75-84	1	1	100.	1	1	100	4	4	100	4	4	100	[illegible]	[illegible]	100	[illegible]	[illegible]	100
85-94	4	4	100.	3	3	100.	5	5	100	0	0	0	[illegible]	[illegible]	100	[illegible]	[illegible]	100
95 +	0	0	0	1	1	100.	2	2	100.	0	0	0	0	0	[illegible]	[illegible]	[illegible]	100
Totals	294	53	18.0	220	49	22.[illegible]	341	76	[illegible]	[illegible]	19	[illegible]	224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Total No. of Pts. With 3rd Degree Burns 1307
Total No of Deaths With 3rd Degree Burns 35[illegible]
Mortality 27.[illegible] %

TABLE 3
COMPARISON OF PROBIT EQUATIONS AND LA50's BY AREA BURNED

Age (Yrs)	Total Area	LA50	3rd Degree	LA50
0-4	y = 1.824 + .0881 x	36.1 %	y = 2.944 + .0745 x	27.6 %
5-14	y = 2.638 + .0569 x	41.5	y = 3.044 + .0587 x	33.3
0-14	y = 2.131 + .0733 x	39.1	y = 2.924 + .0673 x	30.8
15-39	y = 2.346 + .0574 x	46.2	y = 2.849 + .0680 x	31.6
15-44	y = 2.422 + .0580 x	44.5	y = 2.876 + .0709 x	30.0
40-44	y = 3.131 + .0488 x	38.3	y = 2.705 + .1125 x	20.4
40-64	y = 2.963 + .0638 x	31.9	y = 3.209 + .0834 x	21.5
45-64	y = 2.945 + .0663 x	31.0	y = 3.310 + .0786 x	21.5
65 +	y = 3.893 + .0864 x	12.8	y = 2.577 + .2834 x	8.5
Overall	y = 2.894 + .0571 x	36.9	y = 3.344 + .0655 x	25.3

y = Probit; x = %Arrea Burned

TABLE 4
NUMBER OF PATIENTS AND MORTALITY BY RACE AND SEX

AGE	CAUCASIAN MALES			NEGRO MALES			CAUCASIAN FEMALES			NEGRO FEMALES		
(Yrs)	No. of Pts.	Deaths	% Mortal	No. of Pts.	Deaths	% Mortal	No. of Pts.	Deaths	% Mortal	No. of Pts.	Deaths	% Mortal
0-4	142	9	6.3	81	7	8.6	125	6	4.8	146	33	22.7
5-14	49	3	6.1	84	13	15.5	44	4	9.1	98	29	29.6
15-39	162	20	12.3	166	27	16.3	65	16	24.6	113	17	15.0
40-64	105	19	18.1	144	38	26.4	46	13	28.3	72	16	22.[illegible]
65+	32	10	31.3	77	44	57.1	27	16	59.2	54	29	53.[illegible]
Total	490	61	12.4	552	129	23.4	307	55	17.9	482	124	25.7

TABLE 5
LA_{50}'S BY RACE AND SEX

AGE	CAUCASIAN MALE	NEGRO MALE	CAUCASIAN FEMALE	NEGRO FEMALE
0-4 Yrs.	44.2%	35.9%	36.4%	31.2%
0-14	48.8	37.4	36.4	33.5
15-39	48.8	39.5	46.0	53.7
40-64	39.2	25.2	29.7	25.6
65+	17.4	9.6	16.6	11.9
Overall	44.8	32.5	39.3	35.1

TABLE 6
TIME OF ADMISSION POST BURN

% Area Burned	2 Hrs.			2-5 Hrs.			6-23 Hrs.			1D-6D			1 Wk. +		
	No. Pts.	No. Deaths	% Mort.	No. Pts.	No. Deaths	% Mort.	No. Pts.	No. Deaths	% Mort.	No. Pts.	No. Deaths	% Mort.	No. Pts.	No. Deaths	% Mort.
0-24	503	22	4.4	238	17	7.1	104	7	6.7	156	9	5.8	320	11	3.4
25-64	123	77	62.6	112	73	65.2	17	15	88.2	13	8	61.5	2	2	100.
65 +	48	48	100.	25	23	92.0	2	2	100.	0	0	0	0	0	0
Total	674	147	21.8	375	115	30.7	123	24	19.5	169	17	10.0	322	13	4.0

TABLE 7
LA50's BY TIME OF ADMISSION POST BURN

Age	2 Hrs.	2-5 Hrs.	6-23 Hrs.	1-6 Days	1 Wk. +
0-4 Yrs.	35.4	41.2		31.7	
15-39	35.8	48.3			
40-64	32.0	28.4	24.2	35.9	
65 +	13.7	15.2	21.7*	11.9	
Overall	35.2	37.4	28.9	34.1	36.8

* 50 Yrs. +

TABLE 8
OVERALL PROBIT EQUATIONS BY TIME OF ADMISSION POST BURN

TIME OF ADMISSION	EQUATION	LA50
2 Hrs.	$y = 2.519 + .0705\ x$	35.2 %
2-5 Hrs.	$y = 3.068 + .0517\ x$	37.4
6-23Hrs.	$y = 2.608 + .0828\ x$	28.9
1-6 Days	$y = 2.941 + .0604\ x$	34.1
1 Week +	$y = 2.871 + .0578\ x$	36.8

y = Probit; x = % Area Burned

TABLE 9
SURVIVAL TIME OF FATAL CASES 1949-1962

Mortality Probability From Grid	Period	0-2 Days	3-7 Days	8-21 Days	22 or More Days	Total Cases	Mean Survival (Days)
0-.4	1949-1952	1	1	7	5	14	32.1
	1953-1957	5	7	8	23	43	31.9
	1958-1962	2	8	21	19	50	21.9
.5-.9	1949-1952	3	8	13	4	28	11.5
	1953-1957	6	11	14	6	37	12.2
	1958-1962	9	16	27	13	65	14.6
1.0	1949-1952	16	10	2	1	29	3.9
	1953-1957	11	22	8	3	44	6.7
	1958-1962	11	16	14	4	45	9.7

TABLE 10
NO. OF PATIENTS AND MORTALITY BY YEAR OF ADMISSION

AREA BURNED	1949-1952			1953-1957			1958-1962		
%	No. of Pts.	No. of Deaths	% Mortal	No. of Pts.	No. of Deaths	% Mortal	No. of Pts.	No. of Deaths	% Mortal
0-4	101	0	0	211	8	3.8	137	6	4.4
5-14	167	6	3.6	238	13	5.5	276	16	5.8
15-24	72	5	6.9	97	13	13.4	114	17	14.9
25-34	31	15	48.4	48	21	43.7	61	29	47.5
35-44	19	6	31.6	27	17	63.0	38	30	78.9
45-54	15	9	60.0	21	17	80.9	18	15	83.3
55-64	19	15	78.9	9	9	100.	20	18	90.0
65-74	9	7	77.8	8	7	87.5	12	12	100.
75-84	6	6	100.	9	9	100.	5	5	100.
85-94	3	3	100.	9	9	100.	9	9	100.
95 +	5	5	100.	5	5	100.	5	5	100.
Total	447	77	17.2	682	128	18.8	695	162	23.3

TABLE 11
PROBIT EQUATIONS AND LA50's BY YEAR OF ADMISSION

YEARS	EQUATION	LA50
1949-1952	$y = 2.773 + .0503\ x$	44.3 %
1953-1957	$y = 2.954 + .0562\ x$	36.4
1958-1962	$y = 2.898 + .0632\ x$	33.2

y = Probit; x = Area Burned

TABLE 12
COMPARISON OF PATIENTS AND MORTALITY

AGE	BULL & FISHER			BROOKE			MCV		
(Yrs)	Number of Patients	Deaths	% Mortal	Number of Patients	Deaths	% Mortal	Number of Patients	Deaths	% Mortal
0-14	1366	46	3.4	238	43	18.1	769	104	13.5
15-44	967	28	2.9	806*	124	15.4	590	101	17.1
45-64	330	24	7.3	56**	22	39.3	282	65	23.0
65 +	144	63	43.7				190	99	52.1
Total	2807	161	5.7	1100	189	17.2	1831	369	20.1

* 15-49 Yrs.
** 50 + Yrs.

TABLE 13
COMPARISON OF OVERALL MORTALITY EXCLUDING AREA GROUPS WITH LESS THAN 1 1/2 % MORTALITY

AGE (YRS)	AREA EXCLUDED	BULL & FISHER		MCV	
		Remaining Pts.	% Mortality	Remaining Pts.	% Mortality
0-14	0-14 %	187	22.4	285	35.4
15-44	0-14 %	97	25.8	248	39.5
45-64	0-4 %	87	25.3	282*	23.0
65 +	None	144	43.7	190	52.1
Overall		515	29.3	1005	36.1

* No Area Group Excluded

BROOKE ARMY MEDICAL CENTER

Age (Yrs)	Area Excluded	Remaining Pts.	% Mortality
0-14	0-10 %	158	27.2
15-49	0-10 %	605	20.5
50 +	0-20 %	30	73.3
		793	23.8

TABLE 14
COMPARISON OF LA50's FOR TOTAL AREA BURNED BY AGE GROUPS

AGE (YRS)	BULL & FISHER	BROOKE	MCV
0-14	49.4 %	48.5 %	39.1 %
15-44	46.4	55.8*	44.5
45-64	27.1	29.0**	31.0
65 +	10.1		12.8

* 15-49 Yrs.
** 50 + Yrs.

BIBLIOGRAPHY

1. Barnes, Benjamin A., Mortality of Burns at the Massachusetts General Hospital, 1939-1954. Ann. Surg. 145:210-22. 1957.

2. Bull, M. P., and Squire, J. R., A Study of Mortality in a Burns Unit, Ann. Surg. 130:160-74. 1949.

3. Bull, J. P., and Fisher, A. J., A Study of Mortality in a Burns Unit: A Revised Estimate. Ann. Surg. 139:269-74. 1954.

4. Finney, D. J. Probit Analysis: A Statistical Treatment of the Sigmoid Response Curve. Ed. 2. Cambridge, U. University Press. 1952

5. Finney, D. J., The Statistical Method in Biological Assay, Ed. 2 Hafner Publishing Company, New York. 1964.

6. Lindberg, Robert B., Moncrief, J. A., Switzer, W. E., Order Stanley, E., and Mills, W. Jrs., The Successful Control of Burn Wound Sepsis, 24th Annual Session, Amer. Assoc. Surg. Trauma, October, 1964, Chicago, Ill.

7. Moyer, Carl, A., An Assessment of the Therapy of Burns: A Clinical Study, Ann. Surg. 137:628-38. 1953.

8. Moyer, Carl A., Aging and Mortality from Thermal Injury, J. Gerontology. 9:456-464. 1954.

9. Pruitt, B. A., Tumbusch, W. T., Mason, A. D., and Pearson, E., Mortality in 1,100 Consecutive Burns Treated at a Burns Unit, Ann. Surg. 159:396-401. 1964.

10. Rittenbury, M. S., Schmidt, F., Maddox, R., Beazeley, W., III, Ham, W., and Haynes B. W., Jr., Factors Significantly Affecting Mortality in the Burned Patient, 24th Annual Session Amer. Assoc. For. Surg. Trauma, October, 1964, Chicago, Ill.

11. Wiedenfeld, S., Uber den Verbrennungstod. I. Abhangigkeit des

Verbrennungstodes von der Grosse der Verbrannter Hautflach, Arch. fur Dermat. u. Syph. 61:33. 1902.

12. Winterscheld, L. C., and Merendino, K. A., Etiology of and Mortality from Burns at a General Hospital, Am. J. Surg. 100:375-80. 1960.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) Medical College of Virginia 1200 E. Broad Street Richmond, Virginia	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP N/A

3 REPORT TITLE

BURN MORTALITY STUDY OF 1831 PATIENTS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Interim Report - October 1964 thru September 1965

5 AUTHOR(S) (Last name, first name, initial)

Rittenbury, Max S; Maddox, Rhoda W.; Schmidt, Fred H.; Ham, William T., Jr.; Haynes, Boyd W.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
22 November 1965	46	12

8a CONTRACT OR GRANT NO DA-49-146-XZ-423	9a ORIGINATOR'S REPORT NUMBER(S) N/A
b PROJECT NO DASA Subtask 03.132	
c.	9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	DASA 1687

10 AVAILABILITY/LIMITATION NOTICES

"Distribution of this document is unlimited."

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
None	Defense Atomic Support Agency

13 ABSTRACT

The medical histories of 1831 burn patients treated at the Medical College of Virginia during the period 1919 through 1962 have been examined by probit analysis. The mortality rate was compared as related to age, total body surface area of the burn, third degree surface area burned, race, sex, time of admission following the burn injury, and the year of admission. There is a relationship between expected mortality, age and total body surface area of the burn. However, the error in expected mortality indicates a need for a more accurate method of prediction. Time of admission to the hospital following the burn and sex were not important, but the race of the patient is of some importance in predicting eventual outcome of the thermal injury.

The LA50 value has been found to be a useful figure to express tolerance of a patient, or a selected group of patients for burn injury.

There is a striking difference between the effects of second and third degree burn injuries in that the partial-thickness injury is rarely lethal.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Burns Total Body Surface Area Mortality Second Degree Burn Third Degree Burn Partial Thickness Medical Histories Age						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

UNCLASSIFIED
Security Classification